

**Notes on the genus *Pachypsylla* of Japan,
with description of a new species
(Homoptera : Psyllidae)***

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日本産エノキカイガラキジラミ属について
(半翅目：キジラミ科)

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エノキカイガラキジラミ属 (*Pachypsylla*) は、東アジアと北アメリカのみに隔離分布するグループで、日本からはこれまでエノキカイガラキジラミ (*P. japonica*) の1種だけが知られていた。このほど薄葉重氏により、埼玉県で近縁の別新種が発見されたので、若干の生態的知見をも加えて、クロオビカイガラキジラミ (*P. usubai*) として記載した。前者は年2化性であるのに対して、後者は年1化性であること、幼虫が形成するゴールや殻 (lerp) に顕著なちがいがみられるなど、興味深い相違点がある。両種の形態を詳細に比較したところ、後者は前者から分化したものであると、結論するにいたった。両種の分布は明瞭に異所的で、その境界はフォッサマグナの西縁にある糸魚川—静岡構造線である可能性が強いが、なお今後の調査にまつところが大きい。両種とも成虫の移動性が極端に小さく、食樹のエノキは普遍的に分布しているにもかかわらず各地の分布が遺存的であることから考えて、これら2種の分布は、気候的要因よりも地史的要因により強く影響をうけていると思われる。エノキカイガラキジラミ (*P. japonica*) について、その後判明した分類学的・生態学的知見をもあわせて記述した。

The genus *Pachypsylla* is a small genus belonging to the tribe Pachypsyllini of Psyllinae and is composed of seven species from North America and only one species from Japan. All of them are gall-forming species strictly associated with hackberries, *Celtis* spp. and the unique Japanese species, *P. japonica* has both gall- and lerp-forming habits. Not adult but galls, lerps and nymphs of this genus were so far known from E. China and Korea. Those should be identified as *P. japonica* in structures of galls and lerps, but the determination still waits further material of adults.

Recently the second new species of this genus was discovered by Mr. Shigeshi USUBA at Ôyaba, Urawa City near Tokyo. It also inhabits the Japanese hackberry, *Celtis sinensis* var. *japonica* and nymphs are gall- and lerp-formers as well as those of *P. japonica*. This beautiful psyllid with remarkable maculation of dark brownish fasciae on forewings looks much different from *japonica* at a glance, but resembles the latter in structures. However, it can be distinguished from *japonica* in characters of forewings and genitalia, as well as in structures of galls and lerps. So far known, the

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distribution of both species in Japan is allopatric, as the present new species occurring around Tokyo, central Japan only and *japonica* occurring west of Nagano Prefecture in the south-western Japan. It is most interesting that this new species seems to be univoltine and *japonica* is bivoltine. In the present paper, this new species is described with some biological information obtained mostly by Mr. USUBA and its systematic relationship with *japonica* is discussed.

For these ten years various additional information on *P. japonica* has been accumulated. For example, this psyllid has the seasonal forms and the autumnal form has sexual dimorphism in wing maculation. Hibernation takes a place in the egg stage and the autumnal form passes summer in the second instar with presumable diapause period. As for its distribution some other localities have been added. Those further taxonomical and biological details are given in the present paper, though parts of them were published already (MIYATAKE, 1977).

***Pachypsylla usubai* sp. nov.**

[Japanese name : Kuroobi-kaigara-kijirami]

Color : General color yellowish to light brown with markings of brown to dark brown. Antenna wholly light brown with an apical segment sometimes brownish; vertex yellowish with remarkable markings of black to dark brown submarginally as figured (Fig. 1-HD); genal cones entirely yellowish; eyes brown to dark brown; ocelli red. Pronotum yellowish brown, with a dark brownish band posteriorly. Praescutum yellowish with an anterior brownish marking centrally. Mesoscutum dark brownish, with several narrow and obscure linear markings of light brown dorsally, with yellowish portion antero- and postero-laterally; mesoscutellum yellowish brown, with posterior margin brownish; metascutellum entirely yellowish; mesothorax with anterior epipleurite distinctly black. Forewing somewhat white and nearly transparent, with characteristic band-like maculation of dark brown basally and apically (Fig. 1-FW, Pl. 18-A~C); veins light brown except for maculated portion which are dark brown. Hind wing transparent, with transverse brownish fasciae subapically and along Cu as figured (Fig. 1-HW); veins yellowish. Legs light brown, with tibiae sometimes brownish outwardly in case of matured forms. Abdomen dark brown with transverse stripes of lighter brown, uniformly light brown in a teneral form; male genitalia light to red brown, with apical epiphysis of lighter brown; female genitalia brown, darker dorsally, with many brush-like hairs of shiny brown ventro-caudally.

Structure : Head small, nearly $2/3$ as wide as thorax, strictly vertical. Vertex somewhat quadrate, nearly $2/3$ as long as wide, anterior margin wider than posterior margin, slightly incised medially on posterior margin, more or less rugose, with shallow discal

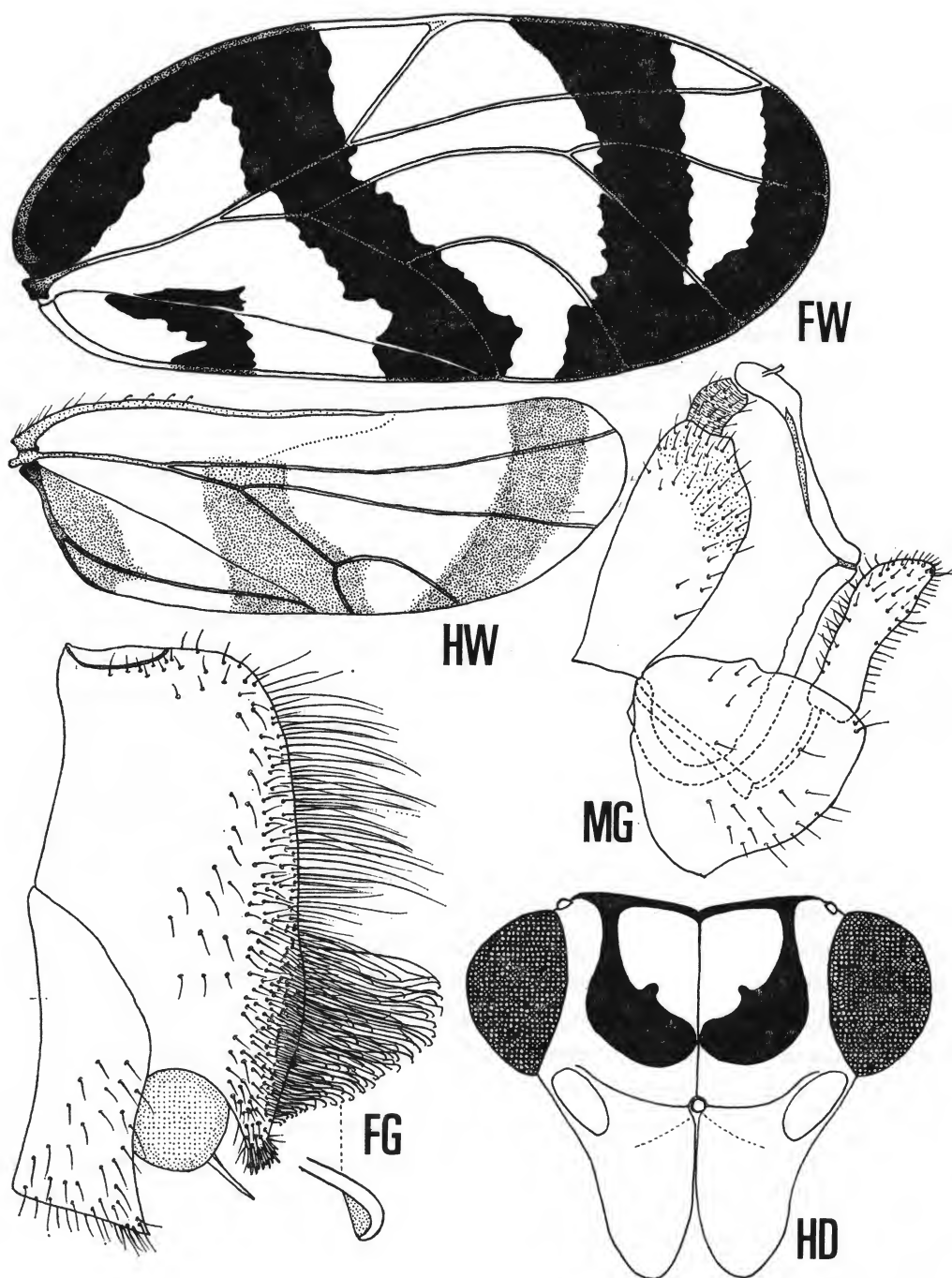


Fig. 1. *Pachypsylla usubai* sp. nov. FW, forewing (male); HW, hind wing (male); HD, head (female); MG, male genitalia; FG, female genitalia (in less magnification than male genitalia).

impressions, sparsely pubescent, rounded down to genal cones anteriorly. Genal cones (Fig. 1-HD) broad, slightly divergent, blunt apically, slightly shorter than vertex, depressed from plane of vertex, with long and dense pubescence. Antenna short and slender, nearly 1.3 times as long as width of head, with 1 long and 1 short setae at apex, segment X remarkably short, apex of each segment with several setae, relative length of antennal segments as follows: 3 : 3 : 10 : 7 : 5 : 5 : 4 : 4 : 2 : 1.

Thorax huge, very strongly arched, shortly and sparsely pubescent dorsally, laterally and ventrally; pronotum vertical, nearly on same plane of vertex, about half as long as vertex; praescutum half as long as wide, descending anteriorly; mesoscutum magnificent, strongly convex, much wider than long, nearly $2/5$ as long as wide; mesoscutellum rectangular, half as long as wide; metascutellum smaller, rectangular, nearly half as long as wide. Forewing large, rather wide basally, widely rounded apically, about 2.4 times as long as wide, membrane slightly rugose, veins raised from surface and biserially set with small setae; pterostigma almost obsolete; Rs rather short, ended much before wing apex; M subparallel with R and Rs, arched, $2/3$ as long as Rs; M_{1+2} conspicuously sinuate, ended near wing apex; Cu_1 subparallel with Cu_2 ; relative length of veins M+Cu, Cu, Cu_2 as 7 : 10 : 12; medial cell distinctly larger than cubital; cubital cell elongate; clavus ended at apex of Cu_2 . Hind wing large, nearly $3/4$ as long as forewing, 2.8 times as long as wide, with psylline venation, R+M+Cu heavily sclerotized, Cu_2 curved outward, S+Sc with 5 hooked frenula and 8 straight microsetae basally. Legs stout, pubescent; posterior tibia without basal spur, with 1 outer, 7 posterior and 2 inner spines at apex; proximal segment of metatarsus with two apical spines, one inner and the other outer; meracanthus prominent, projected ventro-caudad, somewhat constricted basally, rounded or subacute at apex. Abdomen (excl. genital segments) short, slightly longer than half as long as thorax, with pubescence dorsally and ventrally.

Male genitalia (Fig. 1-MG) moderate in size, half as long as the rest of abdomen, hairy; proctiger in lateral view rather slender, nearly 1.6 times as long as forceps, roundly produced caudad, pubescent in apical half, with a distinct apical epiphysis which is stout and slightly flexed caudad; anus opened at apex of apical epiphysis; forceps in lateral view nearly parallel-margined, slightly narrower than apical portion, with blunt apex slightly flexed caudad, with long pubescence, in caudal view nearly parallel, with apical portion arched and tapered to acute and touched apices, with inner surface bearing many short retrorse setae; aedeagus long, basal segment nearly 2 times as long as apical segment which is enlarged apically; subgenital plate subtriangular in lateral view, with dorsal margin sinuate, with ventral margin slightly produced caudad, sparsely pubescent.

Female genitalia (Fig. 1-FG) large but short, peculiarly specialized in shape and structure; dorsal valve in lateral view rather elongate, nearly half as long as high,

caudal margin almost vertical, with long hairs along posterior margin and many curling hairlike setae on ventro-caudal portion, apex with many short and strong brush-like setae, in caudal view median depression prominent, with long pubescence; inner valve slightly longer than dorsal valve apically; ventral valve very small, elongate-triangular in lateral view, projecting ventro-caudad, acute at apex.

Length of body ♂ 2.0–2.5 mm, ♀ 3.0–3.4 mm (to tip of folded wings ♂ 3.7–4.1 mm, ♀ 4.6–4.8 mm); length of forewing ♂ 3.2–3.5 mm, ♀ 4.0–4.3 mm; width of forewing ♂ 1.3–1.5 mm, ♀ 1.6–1.7 mm; length of hind wing ♂ 2.5–2.6 mm, ♀ 3.0–3.2 mm; width of hind wing ♂ 0.8–1.0 mm, ♀ 1.0–1.1 mm; length of antenna ♂ 1.0 mm, ♀ 1.0–1.1 mm.

Holotype ♂: Ôyaba (大谷場), near Minami-urawa, Urawa City, Saitama Pref., 19. vi. 1978, on *Celtis sinensis* var. *japonica*, S. Usuba leg. (preserved in the collection of the Osaka Museum of Natural History).

Paratopotypes: 42 ♂ 22 ♀, same data as the holotype. 1 ♀, Ôyaba, Urawa City, 3. vii. 1977 (nymph), emerged on 10. vii. 1977, on *C. sinensis* var. *japonica*, S. Usuba leg. Galls & lerps, Ôyaba, Urawa City, 28. vi. 1977 and 19. vi. 1978, S. Usuba leg.

Lerps & nymphs, Kizoro, Kawaguchi City, Saitama Pref., 1 & 19. vi. 1978, S. Usuba leg. Galls, Minamitama High School, Hachiôji City, Tokyo Metro., 29. viii. 1978, S. Usuba leg. Galls & lerps, Amatsu-kominato ~ Amatsu, Awa-gun, Chiba Pref., 21. viii. 1978, S. Usuba leg. Galls & lerps, foot of Mt. Tsukuba, Ibaragi Pref., 26. viii. 1977, Y. Miyatake leg.

Galls and lerps collected at Ôyaba of Urawa City, Kizoro of Kawaguchi City, Hachiôji City, Amatsu of Chiba Pref. and Mt. Tsukuba of Ibaragi Pref. were identified as those of the present species basing upon shape, structure and size of them.

Distribution: Central Japan (Saitama Pref., Tokyo Metro., Chiba Pref., Ibaragi Pref.).

Host plant: "Enoki" — *Celtis sinensis* var. *japonica* (PLANCH.) NAKAI [Ulmaceae].

This species resembles *Pachypsylla japonica* in general shape, but differs from it in being a little smaller and in having forewings with characteristic maculation of dark brown, a comparatively shorter Rs and M_{1+2} ended at wing apex, hind wings with brownish maculations, male forceps which are conspicuously enlarged apically, and dorsal valve of female genitalia which is more elongate and straight at caudal margin.

General biology of *Pachypsylla usubai*

According to Mr. USUBA, this species seems to have only one generation a year, although its relative species, *P. japonica* has two generations a year. Adults emerge from the middle of June to early in July. They may copulate soon after emergence, and females may start laying eggs. Although eggs have not been found yet, eggs may pass over summer and fall until next spring. It is quite possible that hibernation takes a place in the egg stage, since there is no evidence of appearance of adults or

nymphs of the following generation. Eggs may hatch sometime late in April to early in May, and reach maturity early in June anyway. A nymph lives on the undersurface of a leaf covered with a peculiar shell-like lerp, forming a small pouch gall on the upper side of a leaf. Usually one lerp can be found on one leaf. A nymph is situated at the opening of gall in the supine position between a outside lerp and a thin wax membrane which closes the opening of gall and is passed through by a rostrum of nymph for sucking. A lerp is constructed by continuous addition of layers, containing its exuviae of each stage. When development is complete the fifth instar nymph leaves its lerp and settles down in an exposed position on the undersurface of leaf where moulting to adult occurs.

Gall: Color usually more or less yellowish green, sometimes not discolored but green; 2.5-3.5 mm in diameter; process small, not conspicuously projected (Pl. 18-D), 1-2 mm in length, usually about 1 mm, never horn-like as in *P. japonica*, apex subacute or blunt.

Lerp: Color whitish, waxy, more or less thick; full-grown one small, 2.5-3.5 mm in diameter (nearly half as large as those of *P. japonica*), usually subcircular, sometimes oval or fan-shaped, moderately convex as in the autumnal lerp of *P. japonica*. A lerp is constructed by addition of usually eccentric and sometimes concentric layers of exudation (Pl. 18-E). Among 33 lerps examined, 25 lerps were eccentric as in the autumnal lerps of *japonica* (Pl. 18-H · I) and only 8 lerps were concentric as in the summer lerps of *japonica*. It may cause to the limited capacity of the small and low gall.

Further information on *Pachypsylla japonica*

Autumnal form: When the original description of this psyllid was made, only adults of the the summer form were available (MIYATAKE, 1968). Subsequently adults of the autumnal form were found and it became clear that they were slightly differing from the summer form in size and wing maculation. They are a little bigger than the summer form especially in size of wings. Measurements are given as follows.

Length of body ♂ 2.5-2.9mm, ♀ 2.5-3.0mm (to tip of folded wings ♂ 4.0-4.4mm, ♀ 4.5-5.1mm); length of forewing ♂ 3.6-4.0 mm, ♀ 4.1-4.5 mm; width of forewing ♂ 1.5-1.6mm, ♀ 1.7-1.9 mm; length of hind wing ♂ 2.6-3.0 mm, ♀ 3.0-3.5 mm; width of hind wing ♂ 0.9-1.0mm, ♀ 1.0-1.1mm; length of antenna ♂ 1.2-1.3mm, ♀ 1.2-1.3mm.

There is a remarkable sexual dimorphism on wing maculation (MIYATAKE, 1977). In male, forewing is nearly uniformly dark brown as in the summer form, with only a small transparent portion at apex of Rs in addition to basal one. In female, forewing is not uniformly dark brown, but with wide transparent portions medially and apically as shown in pictures (Pl. 18-F · G).

Specimens of the autumnal form examined : many nymphs of the 5th instar, Hatsutani, Nose, Osaka Pref., 20. x. 1968, on *Celtis sinensis* var. *japonica*, Y. Miyatake leg. ; 8♂, emerged 25. x. 1968 ; 36♂7♀, emerged 27. x. 1968 ; 5♂22♀, emerged 30. x. 1968. 2♂129♀, Hatsutani, Nose, Osaka Pref., 26. xi. 1968, on *C. sinensis* var. *japonica*, Y. Miyatake leg. 2♂5♀ (1♂1♀ teneral), Ichinotorii, Kawanishi City, Hyogo Pref., 21. xi. 1971, on *C. sinensis* var. *japonica*, Y. Miyatake leg.

Biology : This species has two generations a year at least in the southwestern Japan. Nymphs of the summer form (the first generation) reach maturity by the end of May and adults emerge from early in June to early in July. Females start laying eggs soon after mating. A hatched nymph begins to construct a lerp and soon moults to the second instar. They stay in the second instar for nearly two months. It can be presumed that this long period may include diapause. After becoming the third instar late in September, they emerge in late autumn, from late in October to the middle of November. This autumnal adults of the second generation start mating soon after emergence and females lay eggs on the surface of twig, near winter buds or forks or among setae. Eggs are laid one by one or in groups and turned sideways. Hibernation takes a place in the egg stage on the naked twig of hackberry tree, then. Eggs hatch from middle to late in April. Nymphs grow quickly including rather longer period of the second instar.

Egg : Examining autumnal eggs laid in November, an egg is slender and somewhat spindle-like in general shape (Fig. 2). Measurements are 0.50-0.53mm in length and 0.15-0.17mm in width. It looks slightly broadened basally and subacute at apex. Soon after oviposition an egg is pale yellow and gradually becomes brownish later. Eggs of the summer form which are supposed to be laid in June to July have not been confirmed yet.

Distribution : Japan (Nagano Pref., Mie Pref., Nara Pref., Osaka Pref., Hyogo Pref., Okayama Pref., Tottori Pref., Shimane Pref., Fukuoka Pref.) ; Korea (Kyōngju, Genkyōsan) ; E. China (Shanghai).

Since the original description of this psyllid was presented in 1968, some other localities have been added to its distribution for these ten years as follows.

Further material examined : [JAPAN] 6♂ 8♀, galls, lerps, nymphs, Horcho, Matsue City, Shimane Pref., 13. vi. 1976, on *C. sinensis* var. *japonica*, C. Kadowaki & S. Honjyō leg. 1 gall, Ouchidani Park, Tottori City, 18. vii. 1974, S. Miyamoto leg. Galls & lerps, Hiraoka Park, Higashi-osaka City, Osaka Pref., 30. vi. 1975, on *C. sinensis* var. *japonica*, Y. Miyatake leg. Galls & lerps, Kita-cho, Kawachinagano City, 18. v. 1969, on *C. sinensis* var. *japonica*, Y. Miyatake leg. 1 lerp & 1 nymph (the second or the third instar), Teragaike, Chiyodaicho, Kawachinagano City, Osaka Pref., 5. x. 1979, on *C. sinensis* var. *japonica*, Y. Miyatake leg. Summer galls & lerps, autumnal lerps, Atarasumi, alt. 200 m,

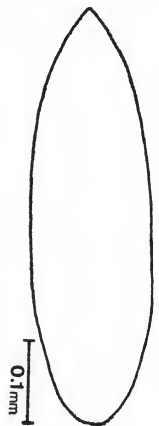


Fig. 2. Egg of *P. japonica* Y. MIYATAKE.

Shimoichi-cho, Yoshino-gun, Nara Pref., 12. i. 1978, on *C. sinensis* var. *japonica*, I. Hiura leg. 2 galls & 1 lerp, Kyûka Park, Yoshinomaru, Kuwana City, Mie Pref., 31. vii. 1976, on *C. sinensis* var. *japonica*, C. Kadowaki leg. (These galls from Kuwana City are small and not horn-like, and resemble those of *P. usubai* in general shape!) [KOREA] Galls & lerps of summer form, lerps of the second instar nymphs of autumnal form, Kyöngju, Kyongsangpuk-do, 20. viii. 1971, on *Celtis* sp., S. Miyamoto leg.

In addition to the above material, some galls and lerps have been obtained at Nariai and Mt. Abuyama of Takatsuki City, Shimo-todoromi of Minoo City and Mt. Nijyo of Minami-kawachi-gun in Osaka Prefecture. As pointed out by USUBA (1979), "Enoki-fukuro-tsunofushi" (horn-like pouch gall of hackberry tree) recorded from Okayama Prefecture and Genkyôsan (元教山), Korea in MONZEN (1932) should be identified as the gall of *P. japonica* according to its description. However, identification based on only galls and lerps is still doubtful and should be confirmed in future in getting adult material.

Discussion

So far known the distribution of *Pachypsylla japonica* and *usubai* in Japan is allopatric (Fig. 3) and rather relic, although their host plant, *Celtis sinensis* var. *japonica* is commonly and widely distributed from the SW Japan north to Niigata-Fukushima Prefectures. At present the border of their distribution appears to be the Itoigawa-Shizuoka Tectonic Line which is considered to be the westmost margin of Fossa Magna. As a collaboration an occurrence of *japonica* at Shimashima Valley of Nagano Prefecture where is very close to but west of the above tectonic line seems to be very important. The reason why the border is not supposed to be the Fossa Magna Region is that several collecting localities of *usubai* stands on the region of a broad sense. Thus there are

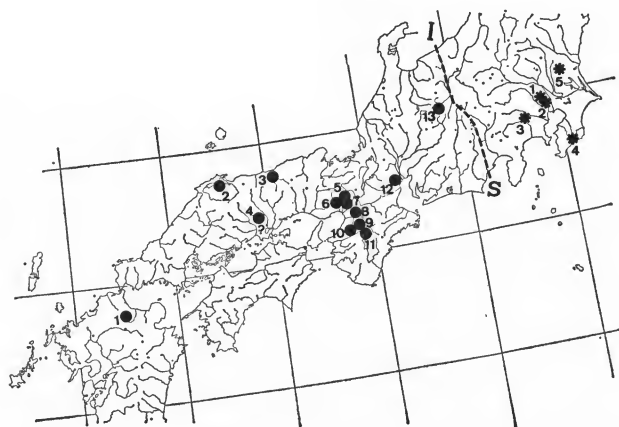


Fig. 3. Collecting localities of two species of *Pachypsylla*.

- : *P. japonica* (1, Mt. Hikosan; 2, Matsue; 3, Tottori; 4, Okayama Pref.; 5, Hatsutani, Nose and Kawanishi; 6, Minoo; 7, Takatsuki; 8, Higashi-osaka; 9, Mt. Nijyo; 10, Kawachinagano; 11, Yoshino; 12, Kuwana; 13, Shimashima Valley).

- * : *P. usubai* (1, Ôyaba, Urawa; 2, Kawaguchi; 3, Hachiôji; 4, Amatsu, Chiba Pref.; 5, Mt. Tsukuba).

I-S: The Itoigawa-Shizuoka Tectonic Line.

great possibilities that the distribution of Japanese species of *Pachypsylla* is regulated geohistorically, as recognized in some other groups of insects, namely, *Mnais* of Odonata, *Henosepilachna* of Coccinellidae and *Carabus* (*Ohomopterus*) of Carabidae in Coleoptera, *leucoptera* group of *Panorpa* in Mecoptera, etc. However, further investigation should be carried out to reveal the true situation.

Considering about the systematic relationship of *japonica* and *usubai*, *japonica* seems to be more primitive in several morphological characters as mentioned below, although both species are closely related and their diversity is minor. The maculation of forewing is rather simple in *japonica* and is more complicated in *usubai*. It is very interesting, however, that wing maculation of the autumnal female of *japonica* resembles that of *usubai* in basic pattern. The wing venation is more or less specialized in *usubai*. In *japonica*, Rs and M are considerably long and marginal cells are in moderate size. On the contrary, in *usubai* Rs and M are shortened and marginal cells become more elongate, especially in medial cell. In male genitalia, an apical epiphysis of proctiger is more developed and forceps have considerable modification in *usubai*. In the female genitalia of *usubai* more modification can be observed in the shape of dorsal valve and in curling hairlike setae on ventro-caudal portion. Only in the structures of gall, *japonica* is more specialized than *usubai*. It may cause to the shorter period of nymphal stage of *usubai* in connection with the seasonal growth of leaves and their gall plasticity of the host plant. Basing on the above tendency of morphological modification, it can be concluded that *usubai* may have been derived from *japonica*. Moreover, such speciation may have occurred in the Japanese Islands, because there is no big morphological gap between them. Their diversity is beyond subspecific, especially in the genital characters, though.

It is most interesting and difficult proposition to consider how *usubai* has been derived from *japonica* in Japan. The most probable process is that the northern population of *japonica* was isolated geographically first and then went to change their voltinism from bivoltine to univoltine life cycle perhaps with climatic pressure. Those circumstances brought them the reproductive isolation and the separated population took a course of speciation. The nature of less dispersion in their behavior and few chance of dispersal in their life cycle with hibernation in the egg stage unlike another psyllids may have performed to push it. As far as only voltinism is concerned, the reverse process from univoltine to bivoltine life cycle can be conjectured also as in many other groups of insects. In several species of psyllids of fundamentally univoltine, some increase of voltinism was observed in the southern part of its range, although their speciation or subspeciation was not clarified yet.

The distribution of the genus *Pachypsylla* is discontinuous, extending over the East Asia and North America. As they are considered to be one of the Arcto-Tertiary elements, the Japanese species of this genus should have been old inhabitants since quite

early time and the history of speciation in *usubai* must have been traced back to earlier than in another psyllids. However, the conclusion still waits further information and study.

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Explanation of Plate 18

- A-C. Adults of *Pachypsylla usubai* sp. nov. (A · B, ♂ ; C, ♀).
 D. Gall of *P. usubai* (dried specimen).
 E. Lerp of *P. usubai* with concentric layers in the first row and eccentric layers in the second and the third rows.
 F-G. Adults of the autumnal form of *Pachypsylla japonica* Y. MIYATAKE (F, ♂ ; G, ♀).
 H. Lerp of the autumnal form of *P. japonica*.
 I. The fifth instar nymphs of *P. japonica* of which lerp are removed on left side.

